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THE MOSQUITOES OF MUSTANG (DIPTERA, CULICIDAE)

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Abstract.—Mustang is one of the northernmost districts in Nepal. Most of it is in the rain shadow of the high Himalaya Mountains, therefore, it has a paucity of rainfall. A mosquito survey of the district resulted in collecting 10 species, four in the genus *Aedes*, five in the genus *Culex* and one in the genus *Anopheles*. The climate and collecting sites are described. Breeding was found up to 3738 m.

Key Words: Mosquitoes, Nepal, Mustang

Mustang is Nepal's northernmost district (see Fig. 1), located in the westcentral sector. Some background on the geography of Nepal will help understand the location and peculiar ecology of Mustang District. Nepal is divided into seven topographical zones, i.e. from south to north: the terai, the Siwalik Range, the Mahabharat Range, the Nepal Midlands, the high Himalayas, the inner Himalayas and the Tibetan marginal mountains (Hagen 1961). We have previously surveyed for mosquitoes in all of these zones, except the last three. Most of Mustang lies in the inner Himalayas, stretches northward to the Tibetan marginal mountains and southward to the Nepal midlands by means of the Kali Gandaki River Valley which cuts through the high Himalayas between the Annapurna Range to the east and the Dhauligiri Range to the west. Both these ranges have peaks of over 8000 m.

Mustang was formerly an independent kingdom with its own monarch but presently it is under Nepal administration. The district government offices are located in Jomsom at 84°17′E and 28°60′N (Fig. 2). Most of the district is above an altitude of 3000 m, although its southern extension along the Kali Gandaki River Valley has elevations as low as 1630 m at Rhuksechahara. The source of the Kali Gandaki River, the main drainage system for central Nepal is in the Tibetan marginal mountains of Mustang.

An impressive religious temple complex in Mustang is Muktinath, important to both Hindus and Buddhists. Since ca. 3000 BC pilgrims have been travelling to this site at 3800 m elevation.

The climate of most of Mustang is dry with annual rainfall of 20 cm. The northern 75% of the district is located in the rain shadow of the Great Himalaya Ranges which prevents the monsoon rains from reaching the area.

Another feature of the weather of the area is the wind. Hagen (1961) explained it this way: "In summer, the sun warms the thin air above the Tibet plateau [about one million km^2 in size] very strongly, for neither

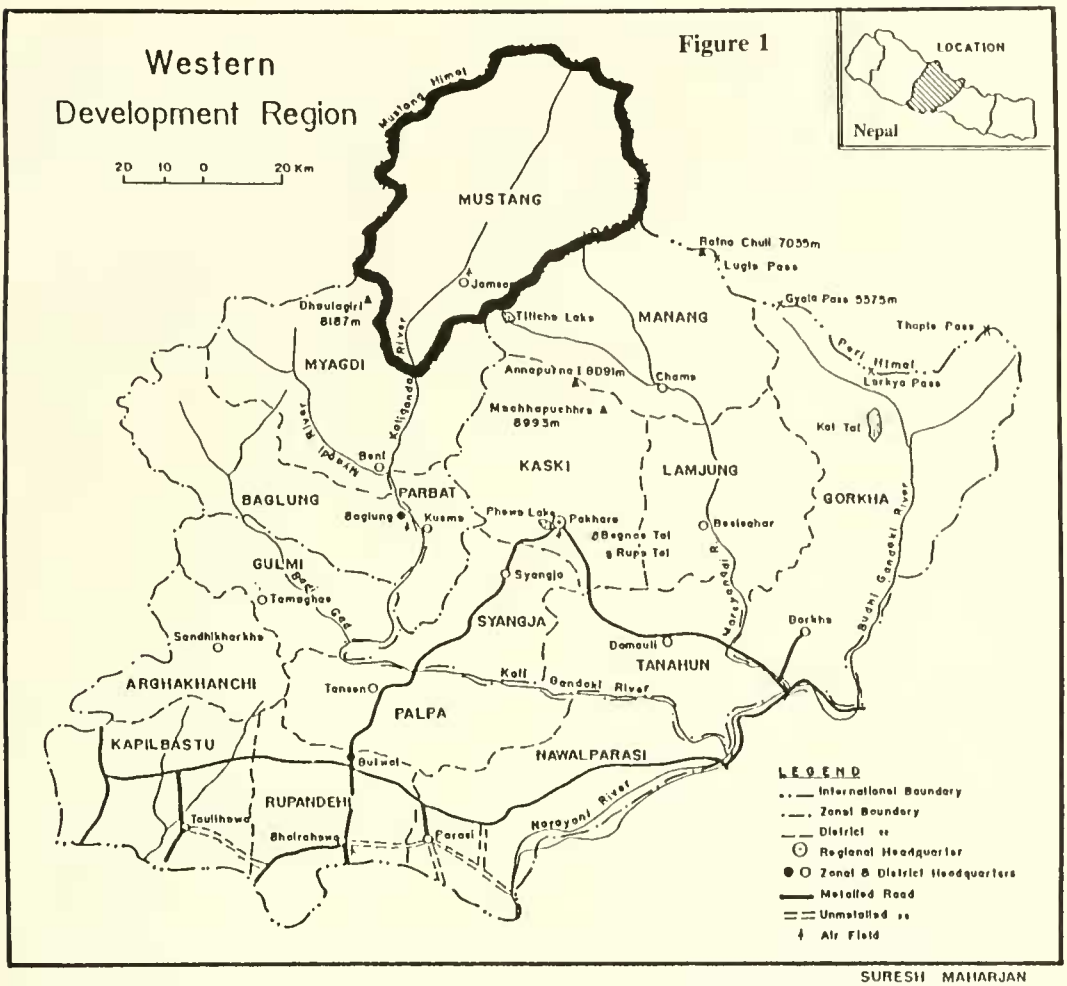

Fig. 1. Map of the Western Development Region of Nepal, highlighting the location of Mustang District.

haze nor clouds impede its scorching rays. The specific weight of the air thus becomes lighter and the air rises. In Tibet and in the inner-Asiatic desert basins intense low pressure is the result, which causes air to be drawn in from all sides. In Nepal, on the southern margin of this area of low pressure, southerly winds prevail in the summer months."

The Kali Gandaki Valley forms a trough in the high Himalaya Mountains making a pathway for the wind thus drawn from lower elevations. So, starting about 1000 h the wind blows at around 30 knots almost constantly until nightfall.

Our objective in visiting this district was to investigate mosquito habitats and species composition as it relates to altitude. So on August 4, 1992 we flew to Jomsom, along with a Nepali entomological technician, and conducted a survey of the area as far north as Muktinath. One of us (GWC) trekked from Jomsom south to Pokhara in order to collect in the lower reaches of the district along the Kali Gandaki Valley.

Along the 32 km trek between Jomsom and the southern border of Mustang, the flora changes dramatically. As one travels south from Jomsom and out of the rain shadow of the high Himalayas, the vege-

Figs. 2–6. 2. Mustang District Headquarters, Jomsom, at 2750 m elevation. The surrounding mountains are mostly devoid of vegetation except in the foreground where a crop of buckwheat was being grown on irrigated terraces. Fig. 3. The stream, Ghatte Khola, and vegetation near Kalopani at 2530 m elevation showing the change to coniferous forests. *Aedes shortti* and *Ae. pseudotaeniatus* were collected in this biotype. Fig. 4. Trail from Chitri to Ghorepani at 1951 m elevation showing change to rhododendron and oak forests. *Aedes dissimilis, Ae. pulchriventer, Ae. pseudotaeniatus, Ae. shortti* and *Cx. palliodothorax* were found in this area. Fig. 5. Pond at Thinigaun at 2800 m elevation where one *Anopheles* species and four *Culex* species were collected. Fig. 6. Pond at Jharkot at 3738 m elevation where *Cx. theileri* and *Cx. vagans* were collected.

Table 1. Species associations from 1992 mosquito collections by field collection numbers (as noted in text).

Species	373	374	375	381	382	383	384	385	389	390
Ae. dissimilis			X							
Ae. pseudotaeniatus	X		X							
Ae. pulchriventer			X							
Ae. shortti	X		X							
An. baileyi				X	X					
Cx. jacksoni				X	X	X		X		
Cx. theileri				X	X					X
Cx. vagans				X	X		X	X	X	X
Cx. pallidothorax		X	X							
Cx. viridiventer		X	X		X					

tation changes to temperate conifers, first to junipers, then to firs and hemlocks (Fig. 3). Beyond the boulder-ridden Kali Gandaki Gorge, subtropical forest of oak, rhododendron and bamboo predominate (Fig. 4). These ecological transformations are presumably related to the amount of rainfall. The temperate vegetation is supported by an annual average rainfall of 100–150 mm, whereas the subtropics receives about 250 mm, annually.

Immature mosquitoes were dipped from habitats, placed in whirlpak bags and stored at our temporary lodgings. Subsequently that were transported to base camp in Pokhara for rearing and identification. The specimens are deposited in the collection of the International Center for Public Health Research, University of South Carolina.

Results

Finding larval habitats in an area where rainfall is minimal was a challenge. We were working in the valley of the Kali Gandaki River which at the time of our visit was in flood stage due to melting snow. It was about 15 m wide as it flowed through Jomsom, our base of operations. Irrigation was widely practiced and terraces were used to grow crops such as buckwheat, corn, wheat, and fruit, i.e. apples, peaches and apricots. We soon discovered that most villages had a pond to water the livestock, for cattle, sheep and horses (Figs. 5, 6). These ponds were the main sources for mosquito production. In one place where breeding was encountered, a section of the flood plain of the Kali Gandaki River north of Jomsom had been artificially inundated in order to grow grass for the livestock. Another larval sample was taken from a large pool at the side of the river. As we ascended from 2750 m to 3800 m on the trek from Jomsom to Jharkot and Muktinath the landscape was barren, practically devoid of vegetation and no water collections were found except in the villages.

We are including one collection made in Myagdi District. It was just across the Kali Gandaki River which formed the border between Mustang and Myagdi districts. We believe these species also occur in the former.

Ten species were collected of which four were in the genus *Aedes*, five in the genus *Culex* and one in the genus *Anopheles*. Species associations from these samples are given in Table 1. The numbers in brackets refer to field collection numbers and abbreviations F = female and M = male.

Notes on Species

Aedes (*Kenknightia*) *dissimilis* (Leicester)

MYAGDI, Ghasa, Kali Gandaki Trail, elev. 1951 m, VIII-6-92, [375] 2F, reared from pupae, ex seepage pool (G. W. Courtney).

Aedes (*Finlaya*) *pseudotaeniatus* (Giles)

MUSTANG, Kobang, Kali Gandaki Trail, elev. 2600 m, VIII-5-92, [373] 1M, reared from pupa, ex stream pool; MYAGDI, Ghasa, Kali Gandaki Trail, elev. 1951, VIII-6-92, [375] 1F, reared from pupa, ex seepage pool (G. W. Courtney).

Aedes (*Finlaya*) *pulchriventer* (Giles)

MYAGDI, Ghasa, Kali Gandaki Trail, elev. 1951 m, VIII-6-92, [375] 2F, 1M, reared from larvae, 1F, 1M, reared from pupae, ex seepage pool (G. W. Courtney).

Aedes (*Finlaya*) *shortti* (Barraud)

MUSTANG, Kobang, Kali Gandaki Trail, elev. 2600 m, VIII-5-92, [373] 3F, 2M, reared from larvae, 1M, reared from pupa, ex stream pool; MYADGI, Ghasa, Kali Gandaki Trail, elev. 1951 m, VIII-6-92, [375] 9F, 6M, reared from larvae, 4F, 5M, reared from pupae, ex seepage pool (G. W. Courtney).

Anopheles (*Anopheles*) *baileyi* Edwards

MUSTANG, Thinigaun elev. 2800 M, VIII-4-92, [381] 1M, reared from pupa, VIII-7-92, [382] 3F, 5M, reared from pupae, ex pond with some aquatic vegetation and human debris (e.g. old shoes, plastic bags) (R. F. Darsie) (Fig. 5).

Culex (*Culex*) *jacksoni* Edwards

MUSTANG, Thinigaun, elev. 2800 m, VIII-4-92, [381] 11F, 11M, reared from pupae; VIII-7-92, [382] 2F, 1M, reared from larva, 19F, 8M, reared from pupae, ex pond with some aquatic vegetation and human debris; Jomsom, elev. 2750 m, VIII-5-92, [383] 1M, reared from pupa, ex seepage spring; VIII-8-92, [385] 2M, reared from larva, 1F, 1M, reared from pupae, ex river margin pool (R. F. Darsie); MYAGDI, Ghasa, elev. 1951 m, VIII-6-92, [375] 1F, reared from pupa, ex animal track rain pool (G. W. Courtney).

Culex (*Culex*) *theileri* Theobald

MUSTANG, Thinigaun, elev. 2800 m, VIII-4-92, [381] 7F, 13M, reared from pupae; VIII-7-92, [382] 11F, 16M, reared from pupae, ex pond with some aquatic vegetation and human debris; Jharkot, elev. 3738 m, VIII-6-92, [390] 1F, 1M, reared from pupae, ex large pond with grassy margins (R. F. Darsie) (Fig. 6).

Culex (*Culex*) *vagans* Wiedemann

MUSTANG, Thinigaun, elev. 2800 m, VIII-4-92, [381] 9F, 2M, reared from pupae; VIII-7-92, [382] 14F, 22M, reared from pupae, ex pond with some aquatic vegetation and human debris; Jomsom, elev. 2750 m, VIII-5-92, [384] 2F, reared from larvae, 1F, 1M, reared from pupae, ex ground pool with much emergent grasses; VII-8-92, [385] 4F, 7M, reared from larvae, 3F, 9M, reared from pupae, ex river margin pool; Jharkot, elev. 3738 m, VIII-6-92, [390] 2F, reared from larvae, 1F, 4M, reared from pupae, ex large pond with grassy margins and clumps of dense emergent grass (R. F. Darsie).

Culex (*Culiciomyia*) *pallidothorax* Theobald

MUSTANG, Kalopani, elev. 2500 m, VIII-6-92, [374] 1F, reared from pupa, ex seepage pool; MYAGDI, Ghasa, elev. 1951 m, VIII-6-92, [375] 1F, reared from pupa, ex seepage pool (G. W. Courtney).

Culex (*Culiciomyia*) *viridiventer* Giles

MUSTANG, Thinigaun, elev. 2800 m, VIII-4-92, [382] 1F, reared from pupa, ex pond with some aquatic vegetation and human debris (R. F. Darsie); Kalopani, elev. 2400 m, VIII-6-92, [374] 1F, reared from larva, ex seepage pool; MYAGDI, Ghasa, elev. 1951 m, VIII-6-92, [375] 1F, 1M, reared from pupae, ex animal track rain pool (G. W. Courtney).

Culex theileri, which had not been collected since 1958 (Darsie and Pradhan 1990), was a common species at the two

highest sites, 2800 and 3736 m. The wing lengths of adults reared from immatures were measured. All the species collected above 2700 m have unusually long wings measuring an average of 4.5 mm. No adults were found during our visit.

Our experience in North America suggests that, as one travels north or ascends to high elevations, only species of the genus *Aedes,* and occasionally *Culiseta,* are found. We therefore expected to collect species of *Aedes* at the highest elevations, but instead the *Culex* mosquitoes predominated.

Acknowledgments

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